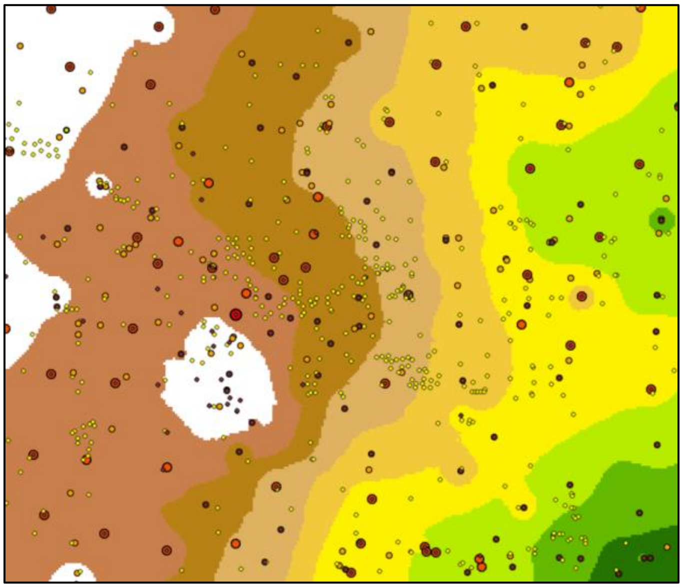
AHGW Pro 1.0 Tutorial

Wells and Time Series

Managing well data and time series data associated with wells



Objectives

Learn how to use the Arc Hydro Groundwater Pro tools to manage well data and time series data associated with wells.

Prerequisite Tutorials

- None

Required Components

- ArcGIS Pro
- Spatial Analyst or 3D Analyst extension
- Groundwater Analyst
- Subsurface Analyst

Time

- 40–65 minutes

1 Introduction

Arc Hydro Groundwater Pro (AHGW Pro) is a geodatabase designed for representing groundwater datasets within ArcGIS Pro. The data model helps to archive, display, and analyze multidimensional groundwater data. It includes several components to represent different types of datasets, including representations of aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models.

The *Arc Hydro Groundwater Pro Tools* help to import, edit, and manage groundwater data stored in an AHGW Pro geodatabase. This tutorial illustrates how to use the tools to manage well data and time series data (transient water level measurements) associated with wells. A basic familiarity with the AHGW Pro data model is suggested, but not required, prior to beginning this tutorial.

2 Outline

This tutorial works with groundwater data from the panhandle region of Texas via the following tasks:

- Importing a set of well data into ArcGIS Pro.
- Modifying the well attributes.
- Generating time series plots of water level data.
- Generating average water level maps for selected periods.
- Building a geoprocessing model to automate running a tool.
- Generating a flow direction map.

2.1 Required Modules/Interfaces

Enable the following components in order to complete this tutorial:

- ArcGIS Pro license
- Arc Hydro Groundwater Tools
- Spatial Analyst or 3D Analyst extension
- AHGW Tutorial Files

The *AHGW Pro Tools* requires installing a compatible ArcGIS Pro service pack. Review the *AHGW Pro Tools* documentation to find the appropriate service pack for the installed version of the tools. *Spatial Analyst* is required for one portion of the tutorial involving interpolation. If *Spatial Analyst* is not installed, skip that portion of the tutorial. The tutorial files should be downloaded to a local computer.

3 Getting Started

Before opening the map, ensure that the *AHGW Pro Tools* are correctly configured.

1. If necessary, launch *ArcGIS Pro*.
2. If on the ArcGIS Pro start page, select **Open another project** in the bottom right corner of the window to open the *Open Project* dialog.
3. If already in the user interface, use the **Open** macro to open the *Open Project* dialog.
4. Browse to the location with tutorial files for this tutorial.
5. Select the file "wells_and_time_series.aprx" located in the *GroundwaterAnalystPro/wells and time series* folder.
6. Click **OK** to import the project.

The initial project will appear similar to Figure 1. Once the file has loaded, a map of the panhandle region of North Texas will appear. The filled polygon represents the boundary of the Ogallala aquifer in Texas. This data was obtained from the Texas Water Development Board Groundwater Database.[1]

[1] See http://www.twdb.state.tx.us/publications/reports/groundwaterreports/gwdatabasereports/gwdatabaserpt.htm

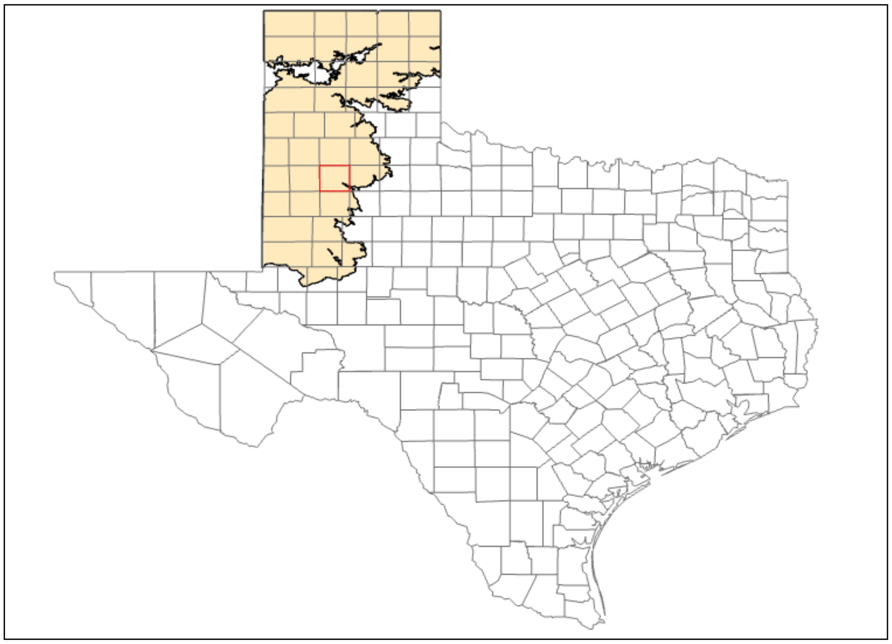


Figure 1 Initial project

Next, ensure that the AHGW Pro tools are correctly configured.

1. In the *Catalog* pane, expand the *Toolboxes* folder.

The *ArcHydroGroundwater.pyt* toolbox should appear under the list of toolboxes. If toolbox is not visible, complete the following:

2. In the *Catalog* pane, right-click on *Toolboxes* and use the **Add Toolbox** command to open the *Add Toolbox* dialog.
3. Browse to the location of *C:\Program Files\Aquaveo\AHGW_ArcGIS_Pro_Python_Toolbox* directory and select and open the *ArcHydroGroundwater.pyt* file.
4. Click **OK** to close the *Add Toolbox* dialog.

With the *ArcHydroGroundwater.pyt* toolbox available, access the Groundwater Analyst tool.

5. Expand “ArcHydroGroundwater.pyt”.
6. Expand “Groundwater Analyst”.

When using geoprocessing tools, it’s possible to set the tools to overwrite outputs by default, and automatically add results to the map/scene. To set these options:

7. At the top of the *ArcGIS Pro* window, select the *Project* tab. From the list on the left, select **Options** to open the *Options* dialog.
8. Select *Geoprocessing* from the list under *Application* on the left of the dialog.
9. Ensure that *Allow geoprocessing tools to overwrite existing datasets* and *Add output datasets to an open map* are turned on.
10. Select **OK** to exit the *Options* dialog.
11. Using the arrow in the upper left corner, return to the main screen.

4 Importing the Well Data

Next, import the well data for Lubbock County. The well data has been downloaded from the above-referenced website to a comma-delimited text file. The AHGW Pro Tools include a tool for automating the import of text data into a AHGW Pro geodatabase.

1. On the ribbon, select the *Map* tab.
2. Click the **Add Data** button to open the *Add Data* dialog.
3. Browse to the data folder for this tutorial and select "Lubbock_well_data.txt" file.
4. Click **OK** to exit the *Add Data* dialog.

A new " Lubbock_well_data.txt" item will appear in the *Standalone Tables* section of the *Contents* pane.

5. Right-click " Lubbock_well_data.txt" and select **Display XY Data** to open the *Display XY Data* dialog.
6. Under *Output Feature Class*, click the browser button to open the *Output Feature Class* dialog.
7. Browse to the data folder for this tutorial and select the "Lubbock_wells.gdb" file.
8. For the *Name*, enter "Wells_Imported".
9. Click **OK** to close the *Output Feature Class* dialog.
10. Click **OK** to close the *Display XY Data* dialog and run the tool.

The new "Wells_Imported" feature class will appear under the "Map" item in the Contents pane and should be visible in map area. In needed, zoom in on the polygon area where the imported wells are located.

The Wells_Imported layer has a geographic projection, and includes all of the attribute fields in the original file. The existing Well layer is also geographic, but GCS North America 1983. It also has only AHGW Pro fields, not all of the attributes found in the original text file. It will be necessary to move all of the features from Wells_Imported and put them into the Well feature class, retaining only the useful AHGW Pro data model fields, not everything that was imported from the text file.

Now to use the Append tool to add features to the well features by doing the following:

11. In the *Command Search* field above the command ribbon, enter "Append" and press *Enter* to open the *Geoprocessing* pane showing the *Append* tool options.
12. For *Input Datasets* use the drop-down menu to select "Wells_Imported".
13. For *Target Datasets* use the drop-down menu to select "Well".
14. For *Field Matching Type* use the drop-down menu to select "Use the field map to reconcile field differences".
15. In the *Field Map*, under *Output Fields*, select *HydroCode*.
16. Select the *Source* tab then use the *Add New Source* drop-down to select the "state_well_number" item and click **Add Selected**.
17. Continue to add the other *Output Fields* as per the table below:

Output Field	Source	Merge Rule
HydroCode	state_well_number	First
AquiferCode	aquifer_id1	First

LandElev	Elev_of_1sd	First
FType	well_type	First
WellDepth	well_depth	First

18. Click **Run** in the *Geoprocessing* pane to run the *Append* tool.

The features from "Wells_Imported" have now been added to the existing "Well" feature class, with the appropriate data fields copied over. The "Wells_Imported" layer can be removed.

19. Right-click on the "Wells_Imported" layer and select **Remove**.
20. Right-click on the "lubbock_county" layer and select **Zoom to Layer**.

The project should appear similar to Figure 2.

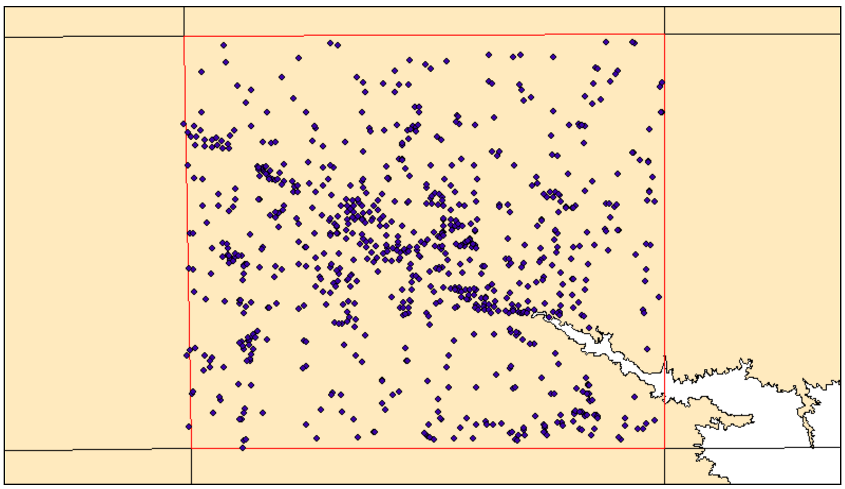


Figure 2 Wells in Lubbock County

5 Using the Feature Type Filter

Features such as wells include an FType field representing the feature type. For wells, this field is often populated with values such as "irrigation", "municipal", etc. The AHGW Pro Toolbar includes a pair of filters that can be used to map only the features in a layer that correspond to a particular type. The Filter creates a simple definition query for the selected value (for example, FType = 'irrigation'). The Texas Water Development Board uses single character codes to identify well types. The four codes used in the wells in Lubbock County are O, S, T, and W and represent the following well types:

Code	Well Type
O	Observation
S	Spring
T	Test hole
W	Withdrawal

Before using the filter, change the symbology so that the wells are colored by type.

1. In the *Contents* pane, right-click on the *Well* layer and select **Symbology** to bring up the *Symbology* pane.
2. Under *Primary symbology*, change the drop-down box from "Single Symbol" to "Unique Values".

3. Change the drop-down box for *Field 1* to be "FType", and change the *Color scheme* if desired to make the wells more visible.

Notice that most of the wells are withdrawal (W) wells. To map wells by type using the filter, do the following:

4. Select "FType" under "Well" in the *Contents* pane. The filter options are dependent on which layer is selected.
5. Change to the *Arc Hydro Groundwater* ribbon tab at the top.
6. Select "FType" from the *Field* drop-down.
7. Select "W" from the *Value* drop-down.

This sets up a new definition query for the selected layer and overwrites any existing definition queries.

8. Repeat step 7 for "T", "S", "O", and "All".

Note that the two *Field* filters can be used to set up a definition query for any field/value combination for any map layer.

6 Assigning HydroIDs

Each feature in an Arc Hydro geodatabase should have an identifier that is unique across the entire geodatabase, not just within a feature class. This unique ID is called the HydroID. The HydroID is used to build relationships between feature classes and/or tables. For example, the HydroIDs of the wells are used to relate the wells to the corresponding water level measurements in the TimeSeries table.

In a typical project, one would normally use the Assign HydroID GW tool in the Groundwater Analyst toolset to generate unique HydroIDs for new features. This tool necessitates some additional steps to relate the wells to the time series data imported in the next step. For the purposes of this tutorial, copy over the values in the HydroCode field to the HydroID field. This will result in unique integer IDs for this exercise.

To copy the values:

1. Right-click on the "Well" layer in the *Contents* pane and select **Attribute Table** to bring up the *Well* attribute table pane.
2. Change to the *Edit* ribbon tab at the top.
3. Right-click on the *HydroID* column header and select **Calculate Field** to bring up the *Calculate Field* dialog.
4. In the *Fields* section, double-click on "HydroCode" to add it to the *HydroID =* section.
5. Click **Apply** to execute the calculation.
6. Click **OK** to close the *Calculate Field* dialog.

When the calculations are complete, the values in the *HydroID* and *HydroCode* columns should match on each row.

7 Importing the Time Series Data

Now that the well features have been imported, import the transient water level measurements into the *TimeSeries* table. Each record in the table will represent a water level measurement at a particular well at a particular time. The records in the *TimeSeries* table will be related to the wells using the *HydroID* field.

1. On the ribbon, select the *Map* tab.
2. Click the **Add Data** button to open the *Add Data* dialog.
3. Browse to the data folder for this tutorial and select the "Lubbock_water_levels.txt" file.
4. Click **OK** to exit the *Add Data* dialog.

Now to append the imported table to the existing *TimeSeries* table by doing the following:

5. In the *Command Search* field above the command ribbon, enter "Append" and press *Enter* to open the *Geoprocessing* pane with the *Append* tool options.
6. For *Input Datasets* use the drop-down menu to select "Lubbock_water_levels.txt".
7. For *Target Datasets* use the drop-down menu to select "TimeSeries".
8. For *Field Matching Type* use the drop-down menu to select "Use the field map to reconcile field differences".
9. In the *Field Map*, under *Output Fields*, select *FeatureID*.
10. Select the *Source* tab then use the *Add New Source* drop-down to select the "state_well_number" item and click **Add Selected**.
11. Continue to add the other *Output Fields* as per the table below:

Output Field	Source	Merge Rule
FeatureID	state_well_number	First
TsValue	depth_from_lsd	First
TsTime	Date_Time	First

12. Click **Run** in the *Geoprocessing* pane to run the *Append* tool.

8 Fixing the TimeSeries Table

The water level measurements are stored in the "TimeSeries" table. Open the table and view the contents.

1. Right-click " TimeSeries" and select **Open** to open the *TimeSeries* table attributes pane.

Notice that two of the fields contain null values. These fields can be populated using the Field Calculator. First, populate the *VarID* field. This field is typically used to identify the type of time series and is an index to a separate VariableDefinition table.

The VariableDefinition table includes a record for each of the different types of time series stored in the TimeSeries table (e.g. "Water level measurement", "TCE Concentration", etc.) and provides information about the units of measurements. To keep this exercise simple, use a single type of measurement in the table (water level) instead of using a VariableDefinition table.

2. Change to the *Edit* ribbon tab at the top.
3. Right-click on the *VarID* column header and select **Calculate Field** to bring up the *Calculate Field* dialog.

4. In *VarID* = section, enter “1”.
5. Click **Apply** to execute the calculation.
6. Click **OK** to close the *Calculate Field* dialog.

The VarID field should now contain values of “1” for all the rows in the table.

8.1 Temporarily Joining Tables

Next, make an adjustment to the water level measurements in the *TimeSeries* table. The water levels imported to the *TsValue* field are depths measured from the top of the well and are expressed as negative values. To get a field representing actual elevations, use the field calculator and add the negative depths to the well elevations. This requires a temporary join. Put the adjusted elevation values into a field called *TSValue_normalized*.

First, do the join.

1. Click the **X** in the top right corner to close the *Table* dialog.
2. Right-click on “ TimeSeries” and select *Joins and Relates* | **Add Join** to bring up the *Add Join* dialog.
3. Below the *Input Join Field* drop-down, for option 1, select “FeatureID” from the drop-down.
4. For *Join Table* option, select “Well” from the drop-down.
5. For *Join Table Field* option, select “HydroID” from the drop-down.
6. Click **OK** to close the *Add Join* dialog and complete the join.
7. If prompted to create an index during the join, click **Yes**.

8.2 Computing Elevations and Removing the Join

Next, compute the proper elevations.

1. Right-click on the *TsValue_normalized* column header and select **Calculate Field** to bring up the *Calculate Field* dialog.
2. In the *Fields* section, double-click on “LandElev” to add it to the *TimeSereis.TsValue_normalized* = section.
3. Click **+** button under the *Helpers* section.
4. In the *Fields* section, double-click on “TsValue” to add it to the *TimeSereis.TsValue_normalized* = section.

The final expression should be: “!Well.LandElev! + !TimeSeries.TsValue!”

5. Click **Apply** to execute the calculation.
6. Click **OK** to close the *Calculate Field* dialog.

Now that the needed calculations have been completed, it is time to remove the join:

7. Right-click on “TimeSeries” in the *Contents* pane and select *Joins and Relates* | **Remove Join** to open the *Remove Join* dialog.
8. For the *Join*, select “Well”.
9. Click **OK** to close the *Remove Join* dialog.

The temporary join has now been removed.

9 Finding Wells with Transient Data

Some of the imported wells have transient water level measurements and some do not. Quickly determine which wells have transient data using the *Make Time Series Statistics* tool in the Groundwater Analyst toolset.

This tool can be used to derive a new feature set from an existing feature set with transient data. The new feature set includes a field representing selected statistics (mean, standard deviation, etc.) of the original transient data. In this case, use the tool to derive a new layer containing only the wells with transient data and with a field representing the average water level over all measurements.

1. In the *Catalog* pane, open the "Time Series" toolset under " Groundwater Analyst" and " ArcHydroGroundwater.pty" in the list of " Toolboxes".
2. Double-click on " Make Time Series Statistics" to bring up the *Geoprocessing* pane showing the *Make Time Series Statistics* tool options.
3. Select "Well" from the *Input Features Related to Time Series Data* drop-down.
4. Select "HydroID" from the *Unique Feature Identifier Field* drop-down.
5. Select "TimeSeries" from the *Input Time Series Table* drop-down.
6. Select "FeatureID" from the *Related Feature Identifier Field* drop-down.
7. Select "TsTime" from the *Time Field* drop-down.
8. Select "TsValue_normalized" from the *Time Series Values Field* drop-down.
9. Select "VarID" from the *Variable ID Field* drop-down.
10. Enter "1" as the *Variable ID*.
11. In the *Statistic (optional)* section, turn on *MEAN*.
12. Click at the right of the *Output Feature Class* field to bring up the *Output Feature Class* dialog.
13. Browse to the data folder for this tutorial and double-click on "Lubbock_wells.gdb".
14. Double-click on the " Data" feature dataset.
15. Enter "water_level_all" as the *Name*.
16. Select "Feature classes (All Types)" from the *Save as type* drop-down and click **Save** to close the *Output Feature Class* dialog.
17. Click **Run** to activate the tool.

A new set of wells should now be displayed on the map (Figure 3).

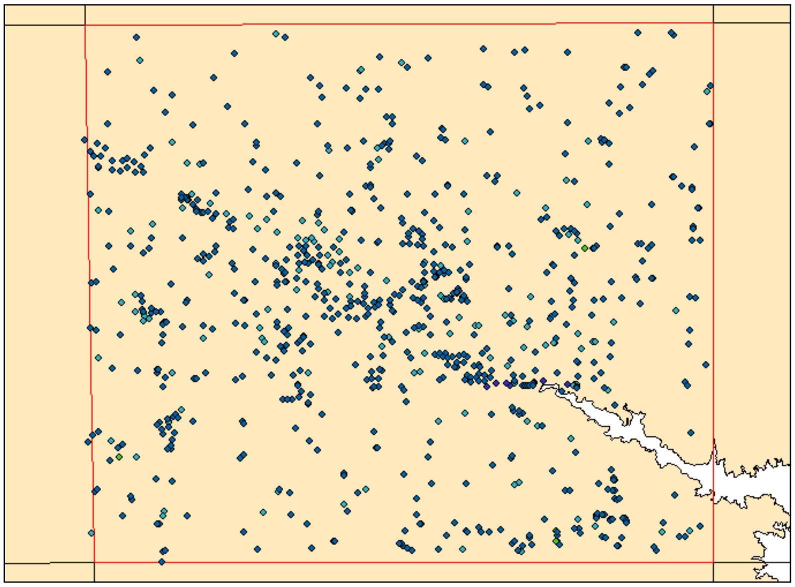


Figure 3 Wells with transient data are now marked

10 Adjusting the Well Display

In addition to the mean water level, the *Make Time Series Statistics* tool generates a new field containing the frequency of measurements (i.e., the number of transient water level values per well). Use symbology to map the sampling frequency.

1. In the *Contents* pane, turn off "Well" to make only the transient wells visible.
2. Right-click on "water_level_all" and select **Symbology** to bring up the *Symbology* pane.
3. Under *Primary symbology*, select "Graduated colors".
4. In the *Fields* section, select "FREQUENCY" from the drop-down.
5. In the *Classes* section, select "4" from the drop-down.
6. In the *Classes* tab, click on the top symbol in the *Symbol* column to switch to the *Format Point Symbol* pane.
7. Select the *Properties* tab.
8. Enter "4.0" for the *Size* and click **Apply**.
9. Click the **Return**  button to go back to the primary symbology page.
10. Repeat steps 6–9 for the second through fourth symbols, entering "6.0", "8.0", and "10.0", respectively, for the *Size*.
11. Select the cyan to purple spectrum (Figure 4) from the *Color Scheme* drop-down.

Figure 4 Standard spectrum

12. Click **OK** to exit the *Layer Properties* dialog.

The wells should now appear similar to Figure 5.

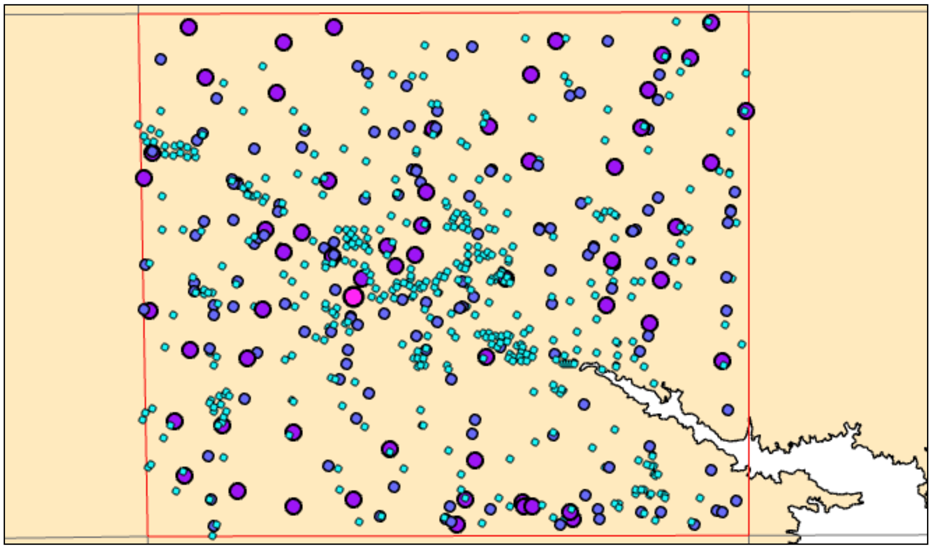


Figure 5 Adjusted display of transient wells

11 Using the Time Series Grapher

When working with transient well data, it is helpful to generate graphs illustrating the change in water level over time. The Arc Hydro Groundwater Toolbar includes an interactive Time Series Grapher tool that can be used to quickly generate time series graphs simply by clicking on wells of interest. Use this tool to explore the Lubbock county well data.

1. On the ribbon, select the *Arc Hydro Groundwater* tab.
2. Click **Time Series Grapher** to bring up the *Time Series Grapher* pane.
3. In the *Features* section, select "water_level_all" from the *Layer* drop-down.
4. Select "FeatureID" from the *Unique ID Field* drop-down.
5. In the *Time Series* section, select "TimeSeries" from the *Table* drop-down.
6. Select "FeatureID" from the *Feature Identifier Field* drop-down.
7. Select "TsTime" from the *Date/Time Field* drop-down.
8. Select "TsValue_normalized" from the *Value Field* drop-down.
9. Turn on *Enable Filtering by Variable ID*.
10. Select "VarID" from the *Variable ID Field* drop-down.
11. Select "1" from the *Variable ID* drop-down.
12. Using the **Select** tool in the *Time Series Grapher* pane, select one of the wells.

In the *Contents* pane, notice a "Charts" item has appeared under the " TimeSeries table.

13. Double-click the " Time Series Grapher" chart item in the *Contents* pane to open a chart window.

A new plot window similar to Figure 6 should appear.

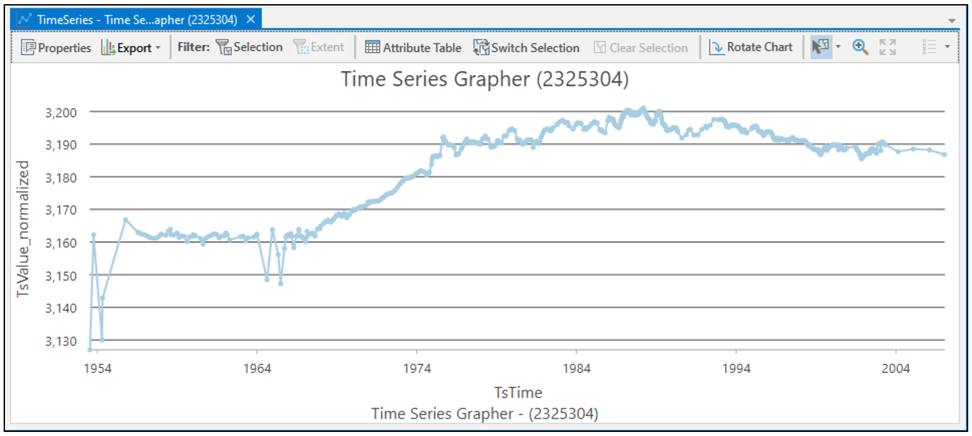


Figure 6 Example of a plot generated with the Time Series Grapher tool

To create a new graph, simply a different. Each graph is stored with the map and can be re-opened by selecting the desired graph from the *Contents* pane.

14. Switch to *Map* tab in the ribbon and click the **Select** tool to deactivate the *Time Series Grapher's* **Select** tool.
15. Close the plot window by clicking on the **X** in the top right corner.

12 Time Series Statistics for a Specific Time Interval

Earlier in this tutorial, the " Make Time Series Statistics" tool was used to derive a new feature class representing the average water levels over the entire set of measurements. The objective was to identify the wells containing transient water level measurements.

Now use that tool to derive a set of features corresponding to mean water levels measured over a specific interval in time (first quarter of the year 2000). Then interpolate those values to a raster to generate a map of water levels for the county for the selected time interval.

1. In the *Catalog* pane, open the "Time Series" toolset under " Groundwater Analyst" and " ArcHydroGroundwater.pty" in the list of " Toolboxes".
2. Double-click on " Make Time Series Statistics" to bring up the *Geoprocessing* pane showing the *Make Time Series Statistics* tool options.
3. Select "Well" from the *Input Features Related to Time Series Data* drop-down.
4. Select "HydroID" from the *Unique Feature Identifier Field* drop-down.
5. Select "TimeSeries" from the *Input Time Series Table* drop-down.
6. Select "FeatureID" from the *Related Feature Identifier Field* drop-down.
7. Select "TsTime" from the *Time Field* drop-down.
8. Enter "1/1/2000" in the *Start Date/Time (optional)*.
9. Enter "3/31/2000" in the *End Date/Time (optional)*.
10. Select "TsValue_normalized" from the *Time Series Values Field* drop-down.
11. Select "VarID" from the *Variable ID Field* drop-down.
12. Enter "1" as the *Variable ID*.

13. In the *Statistic (optional)* section, turn on *MEAN*.
14. Enter “1/1/2000” in the *Start Date/Time*.
15. Enter “3/31/2000” in the *End Date/Time*.
16. Click at the right of the *Output Feature Class* field to bring up the *Output Feature Class* dialog.
17. Browse to the data folder for this tutorail and double-click on “Lubbock_wells.gdb”.
18. Double-click on the “ Data” feature dataset.
19. Enter “well_q1_2000” as the *Name*.
20. Select “Feature classes (All Types)” from the *Save as type* drop-down and click **Save** to close the *Output Feature Class* dialog.
21. Click **Run** to activate the tool.
22. Turn off the “water_level_all” layer in the *Contents* pane.

A new set of wells should appear on the map (Figure 7).

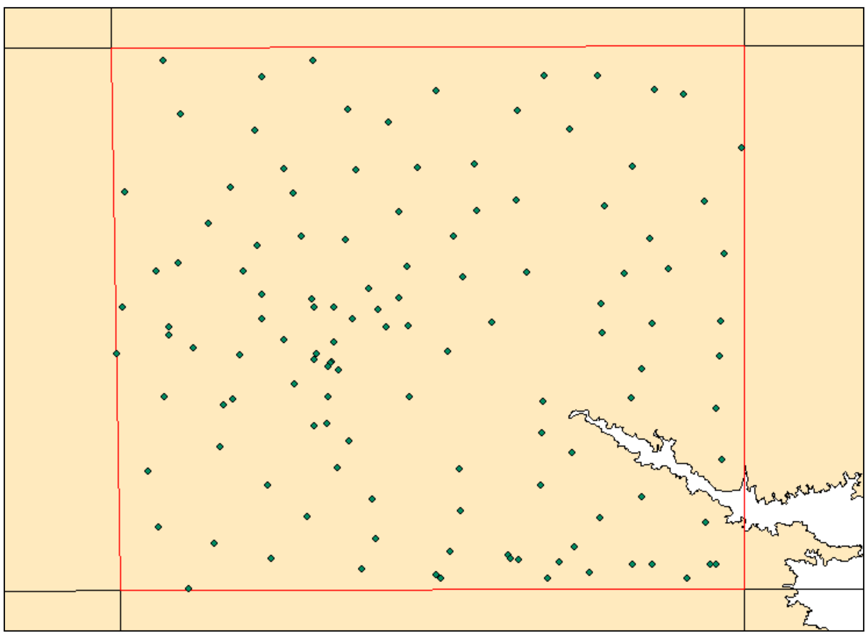


Figure 7 Wells measured within the selected time frame

13 Interpolating Water Levels

The next step is to interpolate the values from the new layer to a raster to generate a map of water levels for Q1 of 2000. This step requires *Spatial Analyst*. If *Spatial Analyst* is not installed, this part of the tutorial cannot be completed. In this case, use the solution files to complete the tutorial. Use the *IDW* geoprocessing tool to perform the interpolation, then set the *Environment* options such that the resulting raster is clipped to the Lubbock County boundary.

1. On the ribbon, select the *Analysis* tab.
2. Click the **Tools** button to open the *Geoprocessing* pane.

3. In the search field of the *Geoprocessing* pane, enter “IDW” and press *Enter*.
4. Click on “ IDW (Spatial Analyst Tool)” to bring up the *IDW* pane.
5. Select “well_q1_2000” from the *Input point features* drop-down.
6. Select “MEAN_TsValue_normalized” from the *Z value field* drop-down.
7. Click at the right of the *Output raster* field to bring up the *Output raster* dialog.
8. Browse to the *wells and time series/Rasters* folder for this project.
9. Enter “well_2000” as the *Name* and click **Save** to exit the *Output raster* dialog.
10. Select the *Environments* tab on the *Geoprocessing* pane.
11. In the *Processing Extent* section, select “lubbock_county” from the *Extent* drop-down.

This causes the interpolation to extend out to the limits of a rectangle encompassing all of Lubbock County.

12. Select *Raster Analysis* and select “Lubbock_county” from the *Mask* drop-down.

This clips the raster to the actual boundary of Lubbock County.

13. Select the *Parameters* tab on the *Geoprocessing* pane.
14. Click **Run** to activate the tool.

Notice a new raster layer called “well_2000” at the bottom of the *Contents* pane. The raster should appear similar to Figure 8.

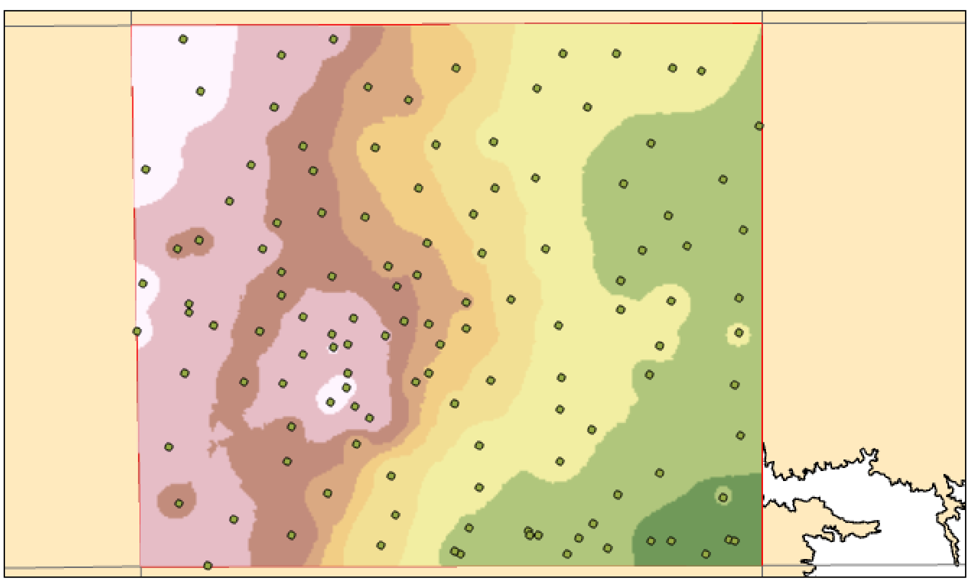


Figure 8 Raster created by the IDW interpolation

14 Using a Mosaic Dataset

Note: This section requires an ArcGIS Standard or Advanced license. If a Standard or Advanced license is not available, this section can be skipped.

A water level raster can be stored in a mosaic dataset. This allows archiving of the raster with the time interval (start date, end date) and other descriptive information that may be useful. Furthermore, a sequence of rasters in a mosaic dataset can be animated using the *Animation* tools.

A raster can be archived in a mosaic dataset using the " Add to Raster Series" tool. Since the geodatabase already contains an empty raster catalog with the appropriate fields, run the tool.

1. In the *Catalog* pane, open the " Groundwater Analyst" toolset under " ArcHydro Groundwater.pty" in the list of " Toolboxes".
2. Double-click on " Add to Raster Series" to open the *Add to Raster Series* tool in the *Geoprocessing* pane.
3. Select "well_2000" from the *Input Raster Dataset* drop-down.
4. Select "RasterSeries" from the *Destination Raster Catalog* drop-down.
5. Select "StartDate" from the *Start Date Field* drop-down.
6. Enter "1/1/2000" in the *Start Date* field.
7. Select "EndDate" from the *End Date Field* drop-down.
8. Enter "3/31/2000" in the *End Date* field.
9. Click **Run** to activate the tool.

Notice the new "RasterSeries" layer in the *Contents* pane. It currently displays a grayscale version of the raster. The color ramp can be changed by modifying the layer properties as described in Section 10, if desired.

To view the contents of the raster catalog:

10. Right-click on the "RasterSeries" layer and select **Open Attribute Table** to bring up the *Table* dialog.
11. Scroll to the right to examine the fields.
12. When finished, close the window by clicking the **X** in the top right corner.

15 Creating a Model to Automate Processes

Since generating water level maps for a specific time interval is such a common procedure, it is useful to build a model that automates parts of the process. This section demonstrates building a model that enables automating the process of running the " Make Time Series Statistics" tool. It is possible to create fairly complex models (and scripts) to automate common tasks.

15.1 Creating the Model

Do the following to create the model:

1. In the *Contents* pane, expand the " Toolboxes" item.
2. Right-click on " Default" under " Toolboxes" and select *New* | **Model**.

15.2 Editing the Model

A new " Model" will appear below " Default"" in the *Catalog* pane and in the main project window.

1. Drag " Make Time Series Statistics" from the *Catalog* pane into the model in the main window.

Tool parameters can also be used as model parameters. In this example, set the input feature classes, tables, and fields as constants and only expose the start date, end date, and output features as model parameters.

2. In the *Model* tab in the main window, select the "Make Time Series Statistics" box, then right-click and select *Create Variable* | *From Parameter* | **Start Date/Time**.
3. Repeat step 2, selecting **End Date/Time** instead.

The parameters may appear on top of each other.

4. Click **Auto Layout** to reorganize the parameters in the model display.
5. Select the "Start Date/Time" parameter, then right-click and select **Parameter**.

A "P" should appear at the top right corner of the "Start Date/Time" parameter.

6. Repeat step 9 for the "End Date/Time" and "Output Feature Class" parameters.

The model should appear similar to Figure 9.

7. **Save** the model.

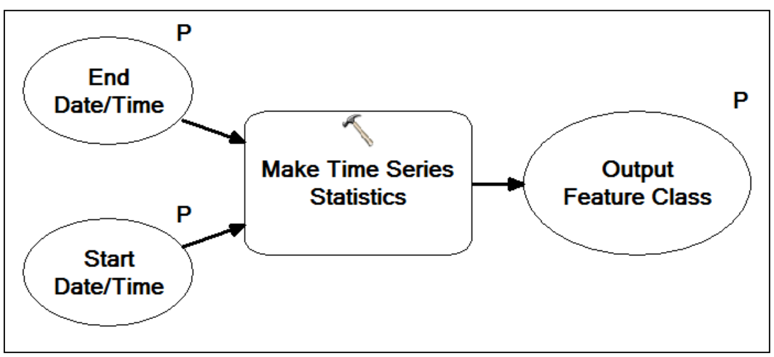


Figure 9 Creating a model including the Make Time Series Statistics tool

15.3 Setting the Tool Parameters

Next, set the other tool parameters.

1. Double-click on the "Make Time Series Statistics" tool in the model to bring up the *Make Time Series Statistics* dialog.
2. Select "Well" from the *Input Features Related to Time Series Data* drop-down.
3. Select "HydroID" from the *Unique Feature Identifier Field* drop-down.
4. Select "TimeSeries" from the *Input Time Series Table* drop-down.
5. Select "FeatureID" from the *Related Feature Identifier Field* drop-down.
6. Select "TsTime" from the *Time Field* drop-down.

7. Select “TsValue_normalized” from the *Time Series Values Field* drop-down.
8. Select “VarID” from the *Variable ID Field* drop-down.
9. Enter “1” as the *Variable ID*.
10. In the *Statistic (optional)* section, turn on *MEAN*.
11. Click at the right of the *Output Feature Class* field to bring up the *Output Feature Class* dialog.
12. Browse to the *groundwater analyst\wells and time series* folder and double-click on “Lubbock_wells.gdb”.
13. Double-click on the “ Data” feature dataset.
14. Enter “well_q1_2001” as the *Name*.
15. Select “Feature classes” from the *Save as type* drop-down and click **Save** to close the *Output Feature Class* dialog.
16. Click **OK** to close the *Make Time Series Statistics* dialog.
17. Click **Auto Layout** to reorganize the parameters in the model display.
18. **Save** the model.
19. Click the **X** in the top right corner of the *Model* dialog to close it.

15.4 Entering the Input Parameters

Now enter the new input parameters by doing the following:

1. In the *Catalog* pane, double-click on “ Model” to bring up the *Model* pane.

Only the *Start Date*, *End Date*, and *Output Feature Class* parameters should be exposed as input parameters (Figure 10). The rest of the parameters are defined in the model and will remain constant.

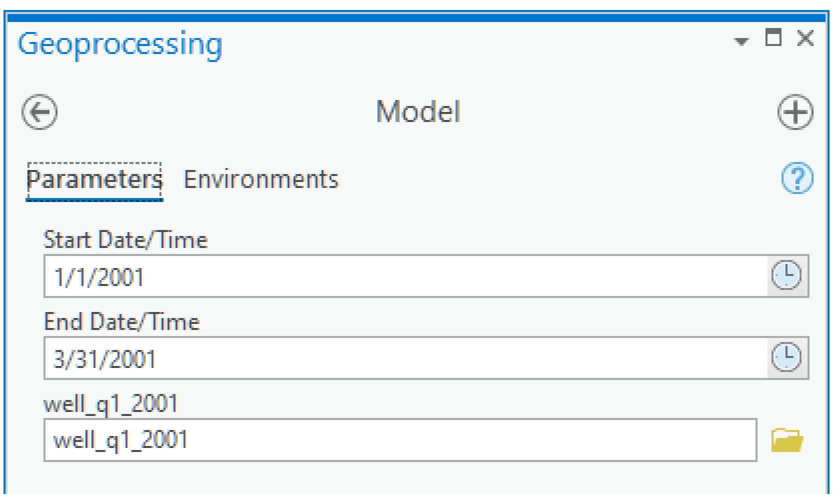


Figure 10 Make Time Series Statistics parameters exposed as model parameters

2. Enter “1/1/2001” as the *Start Date/Time*.
3. Enter “3.31.2001” as the *End Date/Time*.

The *well_q1_2001* input should already be set to the correct feature class. If a different feature class is desired, feel free to change this.

4. Click **Run** to run the model.

A new "well_q1_2001" layer should be added to the map representing the mean water level for the first quarter of 2001.

To run this process for multiple years, batch process the model.

5. Repeat steps 1–4 and use the following table to enter data for each of the first quarter of 2002–2005.

Start Date/Time	End Date/Time	Output Feature Class
1/1/2002	3/31/2002	well_q1_2002
1/1/2003	3/31/2003	well_q1_2003
1/1/2004	3/31/2004	well_q1_2004
1/1/2005	3/31/2005	well_q1_2005

This creates a new feature class for the first quarter of each year from 2002 to 2005.

The process creating water level maps can be automated by creating more complex models and scripts, and then generating a sequence of maps for different time periods. These maps could then be animated using the ArcGIS Animation tools.

16 Generating a Flow Direction Map

As the final step of the tutorial, generate a flow direction map using the **Flow Direction Generator** command in the Arc Hydro Groundwater toolbar. This tool generates a set of flow arrows on top of a water level raster. The arrows are generated as graphic elements and can be managed/deleted using the standard ArcGIS Pro drawing tools. The arrows are generated such that they point in the direction of maximum downward gradient in the water level elevations (i.e., "downhill").

To generate the map:

1. Select the *Map* in the main window.
2. Turn off the "RasterSeries" map layer.
3. Select the "well_q1_2000" raster in the *Contents* pane.
4. In the Arc Hydro Groundwater tab on the riboon, select the **Flow Direction Generator** to bring up the *Flow Direction Generator* pane.
5. In the *Arrow Properties* section, enter "7" as the *Arrow Spacing*.
6. Click **Generate** to generate the flow direction arrows.

The map should appear similar to Figure 11.

Feel free to experiment with the settings. Clicking **Clear** removes the current set of flow direction arrows. Clicking **Generate** clears the current set and generates a new set using the information entered in the *Flow Direction Generator* pane. If the arrows are not cleared before quitting the *Flow Direction Generator*, they will remain visible.

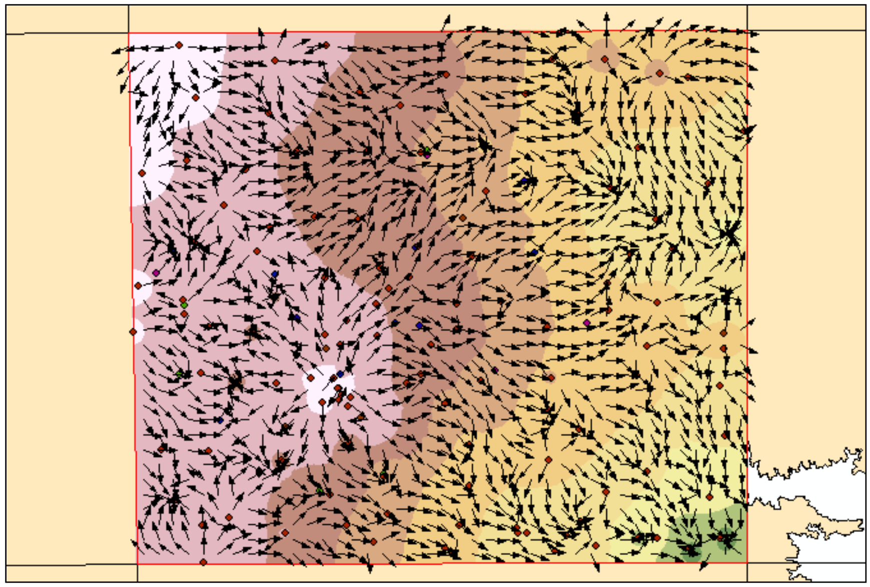


Figure 11 Flow direction arrows

17 Conclusion

This concludes the “Wells and Time Series” tutorial. The following key concepts were discussed and demonstrated in this tutorial:

- The AHGW Pro tools are used to quickly import wells and time series data into an Arc Hydro Groundwater geodatabase.
- The “ Make Time Series Statistics” tool is used to identify wells with transient data and to illustrate the frequency of the data.
- The **Time Series Grapher** tool is used to explore transient data.
- The “ Make Time Series Statistics” tool is used to map statistics (e.g. mean, min, max) values for a specific time intervals. This output can then be interpolated to a raster to generate water level maps.
- Models are used to automate processes.
- The **Flow Direction Generator** tool is used to create a map containing flow direction arrows.